TURBODEN
BIOMASS

ORC COGENERATION SYSTEM FROM YOUR GREEN FUEL.
LEADER IN BIOMASS
SINCE 1980

Since its foundation Turboden has been committed to delivering efficient and reliable cogeneration solutions from renewable sources.
Turboden Organic Rankine Cycle (ORC) plants produce electric power and heat with high efficiency and automatic operation by using any kind of biomass, from virgin wood to organic residues from various production processes.

**KEY POINTS**

- Large range size up to 20 MWe per single shaft
- Generate profit by valorizing a renewable source
- Provide a reliable source of power also for island mode operation
- Reduce specific production cost by decreasing energy demand
- Improve company sustainability
- Reduce CO$_2$ emissions
TURBODEN BIOMASS UNIT DESIGN

CHP SOLUTIONS (low and high temperature cogeneration)

Turboden units generate Combined Heat and Power (CHP) solution - providing either hot water or higher temperature heat medium (e.g. saturated steam or thermal oil). Alternatively Turboden can provide also electric power only solutions.

POWER-ONLY
Electrical efficiency up to 30%

CHP
Electrical efficiency up to 22%
THE ORC CYCLE – HOW IT WORKS

The ORC turbogenerator uses medium-to-high temperature thermal oil to preheat and vaporize a suitable organic working fluid in the evaporator (4>5).

The organic fluid vapor rotates the turbine (5>6), which is directly coupled to the electric generator, resulting in clean, reliable electric power.

The exhaust vapor flows through the regenerator (6>7), where it heats the organic liquid (2>3) and is then condensed in the condenser and cooled by the cooling circuit (7>8>1).

The organic working fluid is then pumped (1>2) into the regenerator and evaporator, thus completing the closed-cycle operation.
EXAMPLE OF A BIOMASS PLANT WITH ORC SYSTEM

HEAT TRANSFER FLUID

The heat from biomass combustion is transferred to the ORC working fluid by means of an intermediate circuit or directly via the combustion gases in direct exchange systems. The media used in the intermediate circuits are thermal oil, saturated steam or superheated water.

*In alternative to more traditional combustion systems, gasification and pyrolysis solutions may be applied.
THREE MAIN POSSIBLE SCHEMES

**POWER ONLY**
- Electric power**: 25-30%
- Thermal power dissipated 70-75%
- 2% losses

**CHP HOT WATER**
- Electric power**: 16-22%
- Thermal power 78% (hot water up to 120 °C)
- 2% losses

**CHP STEAM**
- Electric power**: 15-18%
- Thermal power 82% (steam 5÷30 Bar or thermal oil)
- 2% losses

* Depending on fuel and boiler features
** Depending on size and environmental temperature
*** Depending on heat output temperature

Biomass

Fuel energy input 110% - 120%*

100%

15% losses
KEY FACTORS FOR SUCCESS

- **A HEAT USER TO VALORIZE THE CO-GENERATED HEAT** (CHP configuration is more efficient and remunerative than a power-only one)
- **FUEL AVAILABILITY AT AN AFFORDABLE COST IN THE LONG RUN MINIMIZING TRANSPORT COSTS**
- **SUCCESSFUL BIOMASS PROJECT**
- **HIGH ENERGY VALUE** (renewable incentives, PPA, feed-in tariffs, green certificates, etc.) AND **RELIABLE SOURCE OF ELECTRICITY IN ISLAND MODE SYSTEMS**
APPLICATIONS

TYPICAL FUELS

- sawmill residues or by-products
- bark
- wood dust and chips
- pellet
- furniture waste
- particle board screen dust
- recycled wood waste
- olive pomace and pits
- bruning & trimmings
- barley dust
- malt dust
- rice husks
- almond shells
- sunflower husks
- coffee husks and spent ground
- corn cobs
- coconut shells and husks
- empty fruit bunches
- palm kernel shells
- cotton gin waste, stalks
- paper

HEAT USERS

- FOOD
- RICE
- PELLET
- SAWMILL
- DRYING
- DISTRICT HEATING
- FISH FARMING
- GREENHOUSE
- TRIGENERATION*
- LAUNDRY AND IRONING WORKSHOPS
- MALT PRODUCTION
- MDF/PLYWOOD
- SYNTHETIC FIBERS
- BEER
- CHEMICAL PROCESSES
- PULP & PAPER
- DAIRY
- VEGETABLES OILS REFINING

* with absorption chiller.
### EXAMPLES OF SUCCESSFUL PROJECTS

<table>
<thead>
<tr>
<th>SAWMILL, WOOD-BASED PANEL</th>
<th>RICE, CEREALS, FOOD PROCESSING</th>
<th>DISTRICT HEATING</th>
<th>PELLET AND CHARCOAL PROD.</th>
<th>POWER ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>91 plants</td>
<td>8 plants</td>
<td>167 plants</td>
<td>41 plants</td>
<td>20 plants</td>
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**Fuel**
- SAWMILL, WOOD-BASED PANEL: Wood residues (e.g. bark, sawdust, etc.) from sawmill production process.
- RICE, CEREALS, FOOD PROCESSING: Rice husks, corn cobs, recovered locally from the rice/cereals processing industry.
- DISTRICT HEATING: Various depending on geographical area (typically wood chips).
- PELLET AND CHARCOAL PROD.: Wood residues (e.g. bark, sawdust, etc.) from pellet and charcoal production process.
- POWER ONLY: Various depending on geographical area.

**Power**
- SAWMILL, WOOD-BASED PANEL: Used to feed internal auxiliaries; it can also be used to sustain island operation.
- RICE, CEREALS, FOOD PROCESSING: Used to feed internal auxiliaries; it can also be used to sustain island operation.
- DISTRICT HEATING: Incentives as a renewable source. Also used partly to power internal users.
- PELLET AND CHARCOAL PROD.: Used to feed internal auxiliaries.
- POWER ONLY: Incentives as a renewable source.

**Heat**
- SAWMILL, WOOD-BASED PANEL: Fully used in drying chambers as hot water or low-pressure steam.
- RICE, CEREALS, FOOD PROCESSING: Used for rice processing as hot water or steam, cereal drying.
- DISTRICT HEATING: Used to feed the heating network.
- PELLET AND CHARCOAL PROD.: Used as hot water for wood drying in the process.
- POWER ONLY: No use.

**Note**
- SAWMILL, WOOD-BASED PANEL: Fuel generated as by-product by the industry, heat and electricity valorized internally by the same industry.
- RICE, CEREALS, FOOD PROCESSING: Fuel produced as by-product by the facility, heat and electricity valorized internally by the same industry.
- DISTRICT HEATING: Fuel collected from various sources, heat sold to the local district heating network, electricity partly used internally, and the rest sold to the grid.
- PELLET AND CHARCOAL PROD.: Fuel generated as by-product by the facility, heat and electricity valorized internally by the same industry.
- POWER ONLY: Fuel collected from various sources, electricity sold to the grid. Business model viability subject to biomass price fluctuation.
CHP IN WOOD INDUSTRY

CUSTOMER:
Stia Holzindustrie

COUNTRY:
Austria

STATUS:
in operation since 1999

ORC SIZE:
0.5 MWe

DESCRIPTION:
CHP in a wood factory (wooden flooring and panels)

FUEL:
wood residues

HEAT CARRIER:
thermal oil

WATER TEMPERATURE (IN/OUT):
60 - 90 °C

Longest Turboden ORC in operation

More than 80 plants integrated with wood industries
POWER GENERATION IN SAWMILL

CUSTOMER:
West Fraser Mills

COUNTRY:
Canada

STATUS:
in operation since 2014 – 2015

ORC SIZE:
26 MWe (4 x 6.5 MWe)

DESCRIPTION:
power only in two large sawmills

FUEL:
residues from sawmill process (mainly bark)

HEAT CARRIER:
thermal oil

WATER TEMPERATURE (IN/OUT):
24 - 34°C
CUSTOMER: Athens Energy
COUNTRY: United States of America
STATUS: in operation since October 2016
ORC SIZE: 8 MWe
DESCRIPTION: power only in a wood pellet factory
FUEL: virgin wood
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 25 - 33 °C
CUSTOMER: Starwood
COUNTRY: Turkey
STATUS: in operation since October 2016
ORC SIZE: 5.5 MWe
DESCRIPTION: CHP in an MDF panels factory
FUEL: panels residues and wood waste
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 90 - 110 °C
ADDITIONAL FEATURES: ORC turbine locally produced by Turboden Turkey

About 10 plants (CHP and power only solutions) in Turkey
Tailored solutions for MDF, particle board, plywood factories, etc.
CHP FOR DISTRICT HEATING NETWORK

CUSTOMER: Fernheizwerk Toblach-Innichen

COUNTRY: Italy

STATUS: in operation since December 2003

ORC SIZE: 1.5 MWe

DESCRIPTION: CHP for the district heating network

FUEL: wood chips

HEAT CARRIER: thermal oil

WATER TEMPERATURE (IN/OUT): 60 - 80 °C

Renewable energy for houses heating

166 total plants for district heating
CUSTOMER: Rice Hull
COUNTRY: California, USA
STATUS: Under construction, expected start-up 2021
ORC SIZE: 3.6 MWe
DESCRIPTION: Electric power only with air cooled condenser (no water consumption)
FUEL: rice husk
HEAT CARRIER: thermal oil
POWER GENERATION IN AGRO FOOD INDUSTRY

CUSTOMER: Sobono
COUNTRY: The Philippines
STATUS: in operation since December 2017
ORC SIZE: 5.5 MWe
DESCRIPTION: CHP in a farm for cereals dryers
FUEL: rice husk
HEAT CARRIER: thermal oil
WATER TEMPERATURE (IN/OUT): 40 - 80 °C
SELECTED CUSTOMERS